Versuche über Photographie mittelst der Röntgen'schen Strahlen, or *Experiments on Photography by Means of Röntgen's Rays*

By Josef Maria Eder and Eduard Valenta
February 1896

Translation by Ulrich Ruedel, PhD.
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Introduction by Lita Tirak, PhD. Candidate in American Studies,
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Foreward by Jeff Behary, Director of The Turn of the Century
Electrotherapy Museum

TABLE OF CONTENTS

Introduction by Lita Tirak……………………………………………………i
Foreward by Jeff Behary…………………………………………………....iii
Translation by Ulrich Ruedel………………………………………………...1
Images of the Atlas……………………………………………………….16
Photogravure Plates………………………………………………………17

INTRODUCTION

On December 28, 1895, Wilhelm Conrad Röntgen published his article "On a New Kind of Rays," describing his initial experiments with x-rays. Austria received the news in early January, and consequently its technical schools of higher learning began to conduct experiments. At the Imperial-Royal Institute for Teaching and Experimenting in Photography and Reproduction in Vienna, Josef Maria Eder (1855-1944) and Eduard Valenta (1857-1937) worked together to produce *Versuche über Photographie mittelst der Röntgen'schen Strahlen,* or *Experiments on Photography by Means of Röntgen's Rays*—one of the first x-ray atlases (if not the first) published in the world.

Josef Maria Eder studied photo-chemistry and photometry. In 1882, he published *A Detailed Handbook on Photography*—the first edition of what he would expand into his most important work: *The History of Photography* (1905). From 1892-1905, Eder was a professor of chemistry and physics at the Imperial-Royal Institute for Teaching and Experimenting in Photography and Reproduction (later becoming the Vienna University of Technology), where he was also the founder and director of the school. Eder collaborated with fellow chemist Eduard Valenta as early as 1880, when they prepared an article on iron oxalate and its salts used in photography. Through the 1880s and 1890s, they continued to collaborate on many publications. Beginning in 1892, Valenta served as a professor of photochemistry at Eder's Imperial-Royal Institute for Teaching and Experimenting in Photography and Reproduction. During his tenure, Valenta published books on Lippmann color photography, printing-out papers, sensitizing dyes, spectroanalysis, and photomechanical reproduction. When Eder retired in 1923, Valenta assumed the role of the Institute's director.

Their experiments with x-rays commenced on January 7, 1896. Together, Eder and Valenta replicated Röntgen's process and attempted to improve it photographically with shorter exposure times. They also tried creating x-ray images with a pinhole camera obscura. During their weeks of tests, they accessed the collections of the Imperial-Royal museums in Vienna and produced x-ray images of mummies, different jewels and metals, biological specimens, and human limbs. After considering how x-ray images compressed the layers of the flesh into a two-dimensional form, Eder and Valenta developed a stereoscopic technique which created x-ray images in a three-dimensional illusion. Their publication draws from the disciplines of chemistry, metallurgy, anatomy, medicine, and photography using appropriate terminology. All of these accomplishments have gone unnoticed in most English-language literature. Historians usually cite the atlas for its fifteen beautiful photogravure plates without learning the remarkable experiments during the first months of x-ray research.

In 1922, the Eastman Kodak Company in Rochester, NY acquired most of the x-ray negatives used in Eder's and Valenta's experiments, with the exception of the snake image—which remained in a private collection. Eastman Kodak also obtained a copy of the atlas for their Research Library. During their Research Library's liquidation in 2002, I received this x-ray atlas intact with all its photogravures and still uncut pages.

Ten years later, my academic interests have led me to this project: to translate Eder and Valenta's atlas into English. Ulrich Ruedel, PhD., Consultant in Film Preservation and Analytical Chemistry, has graciously translated the atlas with technical accuracy and skill. Jeff Behary, the Director of the Turn-of-the-Century Electrotherapy Museum in West Palm Beach, Florida, has reviewed Ruedel's translation for historical detail and responds to the newly acquired information in his foreward.

I want to especially thank Raymond Curtin, former Research Librarian at Eastman Kodak, for preserving this atlas and entrusting it to me when Eastman Kodak downsized. This translation project would not have happened without his thoughtfulness.

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May 2012

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FOREWARD

In a famous interview after he discovered a new kind of ray, W. C. Roentgen said, "I did not think: I investigated." Such was the case when, in January 1896, the news of this new discovery spread around the world with an intrigue that surpassed a world full of new promise and life-changing inventions.

If Josef Maria Eder and Eduard Valenta had written this monograph in 1900, science would have considered it an excellent compilation of thoughts on the subject at that time. The fact that they wrote it in February 1896 is astonishing, since the popular newspapers often represented the early years of x-rays as haphazard. To some extent, the representation was true – a majority of people, whether scientists or laymen – sought out to produce the rays with any disposal at their means to do so. With any luck, they might have successfully seen the shadows of the bones of their hands through a fluoroscope – or made simple photographs through items, such as photographing keys through blocks of wood – or their own hands. As the immediate commercial use of these rays intrigued many, inventors developed and placed apparatus on the market often before the technologies were validated in working environments. Few investigators took the time so early on to work out the real problems and science behind producing the rays accurately and repeatedly. Eder and Valenta were exceptions – and in their work, even with simple Hittorf tubes – worked out the problems of out-gassing internal components, the proper processes to evacuate the tubes, the shape and position of the electrodes, as well as the form of the glass bulb itself. Once perfected, they demonstrated the value of this new discovery for photographic, medical/surgical, zoological work, and even Egyptology in the case of an unopened mummy. It would be hard to imagine someone not being inspired by the possibilities of the "X-Ray" after reading this monograph – it is a historical treasure on the topic.

Jeff Behary, Director, The Turn-of-the-Century Electrotherapy Museum

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By Josef Maria Eder and Eduard Valenta (February 1896)
English Translation by Ulrich Ruedel PhD., Consultant in Film Preservation and Analytical Chemistry
Edited by Lita Tirak, Doctoral Candidate in American Studies at the College of William and Mary
In Consultation with Jeff Behary, Director of the Electrotherapy Museum

[PAGE 1] In December 1895, Professor Dr. W.C. Roentgen presented his discovery of a "new kind of rays" to the local "Physical-Medical Society" as a preliminary report in the society's meeting minutes.[1] The physicist focused on investigation of phenomena appearing in evacuated glass tubes when the spark of a Ruhmkorff inductorium or a Holtz induction instrument arcs through such tubes. In this process, if the evacuation of the tube is sufficient, strange rays appear at the cathode (the negative pole) which propagate in the evacuated tube perpendicularly to the cathode surface and, where they hit the glass wall, make the latter illuminate in beautiful green fluorescent light.

The first one to closely investigate such rays emanating from the cathode, so-called cathode rays, was Hittorf in Münster, which is why the evacuated glass tubes supplied with molten-in electrodes are called "Hittorf tubes." In addition to Hittorf, these phenomena were studied by German physicist Goldstein in Berlin, later on by the Englishman [William] Crookes, who called the rays "radiating matter" and, most recently, by physicist Lenard, whose elegant investigation on the cathode rays were duly noted in the literature.

In his [Roentgen's] investigations, the spark of a strong Ruhmkorff inductorium arced through a "Hittorf tube" with the latter wrapped in a little cardboard box; in doing so, he made the strange observation that each time the electric spark arced through the completely light-tight tube, a paper screen coated with barium platinocyanide (a strongly fluorescent substance) positioned in proximity [to the tube] fluoresced brightly, even though neither visible nor ultraviolet rays could have struck the screen. From this, he concluded that some agent must emanate from the Hittorf tube that penetrates the opaque cardboard and, in a manner similar to ultraviolet light, induces a vivid illumination in the barium platinocyanide.

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[1] "Eine neue Art von Strahlen" [A New Kind of Rays], by Dr. W. Roentgen, public professor of the Royal University Wuerzburg, publishing and printing house of the Stabel Court and University Book and Art Shop.

Further investigations by Roentgen revealed that this agent can penetrate any kind of body, but this capability varies substantially with differing materials. This different degree of penetrability was originally estimated by Roentgen by the degree of illumination of a barium platinocyanide screen positioned behind the respective body. Roentgen thus confirmed that paper and wood are highly penetrable; a book of 1000 pages or a strong board [PAGE 2] from soft wood are merely a weak obstacle for the new rays. He further found that these new rays, which he called "X Rays" to distinguish them from the known rays, are weakly attenuated by thick layers of mica. Glass varies in penetrability. Crown glass is more penetrable than flint glass, and further, numerous metals have differing penetrability; thus aluminum in very thin layers lets the rays pass quite easily, as does tin foil, while the denser metals such as iron, lead, platinum silver, gold etc. turned out very impenetrable, and the impenetrability grows with the density, but not proportionally so. To wit, Roentgen found that the penetrability of plates of different thicknesses made from platinum, zinc, lead and aluminum is not equal at all even when the density is.

In this metal experiment series, their salts let the rays pass. Liquids such as water, carbon disulfide turned out very penetrable. The fluorescence phenomenon occurring with barium platinocyanide, when hit by these rays, is not the only discernible one; when hit by the rays, other materials also show fluorescence phenomena, such as lime spar, uranium glass, rock salt etc.

Roentgen found it likely that the rays he discovered can execute heat effects, as these have the ability to be converted into light (i.e. effect fluorescence phenomena). He further found that these rays cannot be refracted, i.e. being deflected by mica, nor hard rubber or aluminum prisms or lenses. Further, he did not succeed in proving a substantial ordinary reflection of the rays, but demonstrated that when a dry plate turned towards the ray source with its glass side, and covered with bare glossy aluminum, iron, platinum, lead or zinc sheet on its coated side was exposed to the effects of

Roentgen's rays, the blackening of the areas of the three lighter metals, especially that under the zinc sheet, is larger than those of the uncovered layers – aluminum had no effect. It seems that lead, platinum and zinc sheets can reflect the rays after all, and indeed later on Carmichael in Lille was able to confirm the reflection of Roentgen's rays by means of a steel mirror. Roentgen further proved that the rays discovered by him are not identical to cathode tube rays, investigated by Lenard in particular, but are distinguished by their non-deflectability by means of a magnet.[2]

Of particular interest is the ability of these rays to have an effect analogous to that of common light rays on silver bromide gelatin plates. To wit, Roentgen observed that the commercially available silver bromide dry plates are quite sensitive to the new rays. This effect enabled him to record his observations by means of photography, and he produced a series of images by means of dry plates enclosed in wooden cassettes in a light tight manner, on which he placed the objects to be studied and exposed everything to the effect of the new rays.

Through the new rays' effect on silver bromide dry plates similar to light rays, Roentgen's discovery obtained the immense importance, applied today for the most diverse areas of scientific research, when only little time has passed since Roentgen's first publication [PAGE 3] on the matter.

Only through the photographic method could Roentgen's experiments obtain results with convincing certainty and conclusiveness, as the results permanently fixed as photograms have to offer. When the first news of Roentgen's discovery appeared in the journals, we felt prompted to undertake experiments in this direction, and began those on January 7 of the current year by mounting a lead grate on a cassette as it is used for conventional pictures, with the gate valve [shutter] above the light sensitive plate, closing the cassette and then exposing it to the rays of a vacuum tube containing argon gas in a very low dilution, which had been almost completely absorbed by the electrodes in spectral experiments, so that the tube, brought in between the poles of the secondary coil of a Ruhmkorff inductorium, would partly glow in green fluorescent light. The effect upon relatively short exposure (20 minutes) was a very beautiful one; the lead grate appeared on the developed plate in focus and clearly imaged. We repeated the experiment with a little key enclosed in a wooden cassette.

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[2] It should be noted that as early as 1886, in a communication to the Berlin Academy of Sciences, E. Goldstein made the observation known that there are two kinds of cathode rays, those that can be deflected with a magnet and those that cannot.

Meanwhile, after seeing Roentgen's images courtesy of counselor Prof. Dr. Sigmund Exner, to whom he had sent them, we repeated the experiment to photograph the skeleton of the human hand and obtained, albeit with a long exposure time (two hours), useful results enabling us to present our images, of which copies were made on silver bromide paper using the development process, next to Roentgen's originals in a plenary assembly of the “Photographic Society” that same night. Then, we continued our experiments with different vacuum tubes; on January 22, a large number of photographs with Roentgen's rays were presented by us in the “Society for Dissemination of Scientific Knowledge,” as well as on February 4 in the plenary assembly of the “Vienna Photographic Society” in the green hall of the Imperial Academy of Sciences, and the means of manufacture was explained by means of projected images. Many of the images that were presented are included in this publication and these images should be good examples of what can be achieved with this method and how Roentgen's discovery can be used for diverse scientific purposes.

In the following, we will describe our experimental setup, as it should not be without interest for those who intend to repeat the Roentgen experiments.

As a source of current, we usually employ the direct current delivered by a dynamo machine of 110 or 220 Volts of voltage, respectively, which flows to the Ruhmkorff inductorium after passing an adjustable resistor.

Our inductorium is of the largest kind, by Keiser & Schmidt in Berlin, and delivers sparks of 25 cm length; as it has a rather strong primary wire conduct (4 mm), we can have 4-20 ampere at 80 volts voltage flow through the primary wire conduct without the apparatus suffering damage, which is how very beautiful results can be obtained especially in the matter of metal sparks at the air. In the current case it proved practical not to exceed a current power above 2 ampere (usually 1 ampere is sufficient);

in contrast

[PAGE 4] it is advantageous to use rather high voltages in the primary winding. However, as is well known, the induction rolls behave differently depending on the kind of their wires' winding. Given the suitable use of the tubes employed, currents of 4 amperes and 6 volts and an inductorium of 5 cm spark sufficient lengths and one obtains a cathode radiation that receives good results in many cases (see page 7).

Using an ordinary Ruhmkorff inductorium, one can also use alternating current. For this purpose, the hammer of the Ruhmkorff inductorium is pressed on by means of the adjusting screw, so that the current can pass the primary winding of the inductorium without interference. Admittedly, using an alternate current, half of the cathode rays gets lost for photographic captures; since there is a continuous alternating of poles, we obtain only one hundred interruptions per minute instead of a thousand, and as a consequence of this, more cathode rays, under otherwise equal circumstances, manifest themselves also by substantially heating up the bottom of the Hittorf tube. Experiments with very high voltage of alternating currents, as they are obtained according to Tesla by means of an oil transformer, did not yield improved results compared to the experimental setup just mentioned. Good results and a substantial shortening of exposure time are obtained with a direct [battery] current that is interrupted in a rapid sequence by means of a rotating interrupting disc, turned into rapid motion by a little electrical engine.

In place of the Ruhmkorff inductorium, a Holtz induction machine or a machine of similar construction can be used; in this case it is recommended to engage a spark gap and drive the machine with a little electrical engine or another fast running engine. Instead of engaging a spark gap in the supply line, it is also sufficient not to connect the supplies directly with the electrode wires, but rather adjust them so that the spark has to jump over. In our experiments with the induction machine we got less favorable results than with Ruhmkorff inductoria of medium arcing distance. At any rate, the kind of stimulus, the shape and the degree of evaporation of the vacuum containers influences the effect obtained.

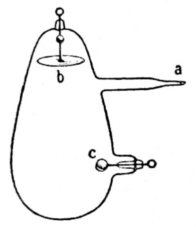

Fig. 1.

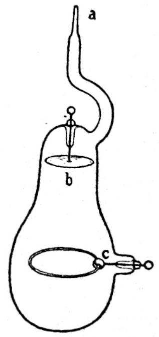

Fig. 2.

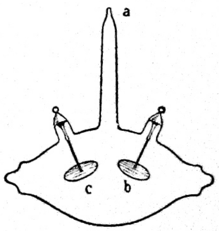

Fig. 3.

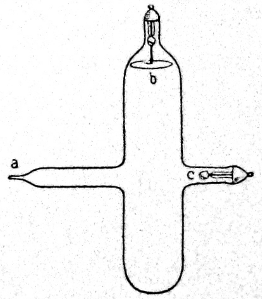

Fig. 4.

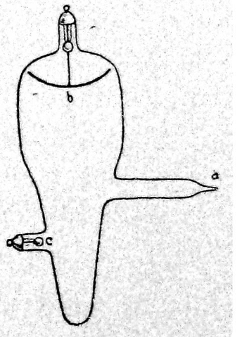

Fig. 5.

As the light source, or rather `ray source,` strongly evaporated glass containers of a special shape are employed. We use glass containers of the shape depicted above (Fig. 1 – 3). These have the shape of a pear and carry on top, melted in at a piece of platinum wire, aluminum sheet discs (b) of 0.5 – 1 mm thickness and 2 – 4 cm diameter. These discs form the cathode and are connected to the molten-in platinum wire by means of a 1 mm strong aluminum wire. Approximately in the middle of these containers, which have a content of ¼ to ½ liter, the anode is placed, also conductively connected to a molten-in platinum wire; it consists either of an aluminum button (Fig. 1 c) or also from, an aluminum disc, or (and this has very well proven of value in our experiments) from [PAGE 5] an aluminum wire ring (Fig. 2, c). This ring, however, must be larger than the cathode disc and mounted in such a manner that, seen from above, it surrounds it as a concentric ring. Fig. 3 shows a shape of the Hittorf tubes as supplied by Dr. Geissler in Bonn; in this form, anode and cathode are equally sized aluminum sheet discs (b and c) and positioned in such a manner that the perpendicular to the surface of the discs, drawn from the circumference of both discs to the lower glass surface, define one and the same area. Substantially better than the latter form is the design which Prof. Kiss in Budapest gives his commercially available vacuum tubes (Fig. 4 and 5).

All of the Hittorf tubes have a glass tube on the side and are fused to a mercury air pump (in fact, usually four next to each other) for the purpose of evacuation. To produce the evacuated volume, we use a Kahlbaum mercury air pump which due to its exquisite design allows the evacuation of larger volumes in a short time. Once the vacuum meter shows a mere 2-3mm, the induction current of a Ruhmkorff inductorium is allowed through one of the containers. In this dilution, the usual Geissler tube phenomena occur: appearance of a rather broad, violet light tuft, etc. On further dilution, the pattern changes, the light tuft broadens further and shows layering. When the dilution is advanced very far, a bundle of straight blue violet rays can be seen running from the cathode (the negative pole), which are perpendicular to the cathode area and bring about a vivid green fluorescence phenomenon where they hit the glass wall, that means in the lower broadest of the [tube] shapes used by us. The violet radiation phenomenon disappears on continued evacuation and in the end nothing is left of the blue stripes; in contrast, the green fluorescence becomes all the more prominent and, upon sufficient evacuation, a little dark spot appears at the lower part of the bulbs in our experiments, which is surrounded by a very brightly shining green ring and which is more or less hot depending on the strength of current applied. With strong high voltage currents, this heat can be so intense it will soften the bulb and indent it as a consequence of the outer air pressure.

To remove any trace of humidity from the glass bulbs, which would affect evacuation, it is necessary to seal a bulb with phosphor pentoxide between the pump and the bulb, to strongly warm the bulbs during evacuation and to send through a rather large current. When the condition of the bulb just described is reached[3], the latter is heated and sealed shut with the help of a glass blower lamp at the place of the connecting tube previously pulled out somewhat.

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[3] We made the observation that the effectiveness of the vacuum tubes in different phases of the evacuation varies depending on the type of Ruhmkorff, or respectively the kind of electrical stimulation, strength and voltage of the current. In our experiments, we empirically tested the relationship of the best phase of evacuation with the quality of the respectively used Ruhmkorff. Prof. Kiss has demonstrated that the exposure time in hand photography can be shortened to a minute. We obtained the same results when evacuation was driven until saturated green fluorescence using a moderate Ruhmkorff (see page 7), while with more high voltage currents the best effect occurred with yellow-green fluorescence.

When using the same inductorium and the same current power in the primary winding of the coil after melting off the bulb as at the time when the latter was still connected to the pump, no change of the phenomenon appears. When a stronger current strikes through, one can easily make the observation that the green color is lost by and by, while the bulb is evenly warmed up and a violet light tuft appears. Probably gasses from the pores of the aluminum escape upon heating the electrodes due to the strong current, which however are absorbed again upon longer action of the bulb, since a bulb used for a long time does not lose the fluorescence phenomenon again even when applying rather strong currents.

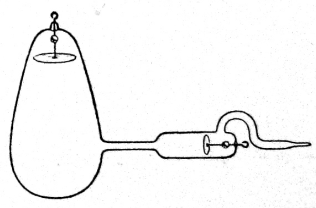

Fig. 6.

[PAGE 6] The absorption of the gases initially occurring in the above bulbs takes place successively upon the longer striking through of the induction spark. Initially a blueish-white light shimmer occurs in them, which unites to a white, intensively shining strip, in case a capillary is present, as is the case I the setup showing in Fig. 6. The spectrum of this stripe shows lines of nitrogen, hydrogen and mercury. Gradually the white light shimmer begins to layer and weak fluorescence phenomena occur, these grow stronger and stronger, the lines and bands of mercury and nitrate disappear – the light in the capillary turns red-violet, finally the hydrogen spectrum also disappears and the bottom of the tube glows in gorgeous green-yellow fluorescent light. Now the Hittorf tube has become useful for our purposes.

Such Hittorf containers show, be it by somewhat deficient evacuation, be it by too weak a current during evacuation, no pure fluorescence phenomena, which can for this reason easily be made useful again in a simple manner when one lets a strong induction spark go through the tube during one or two hours, whereupon usually the blue glowing light initially occurs more strongly, but then gradually disappears and, as described before, makes room for the pure fluorescence phenomena. Should the electrodes become glowing at this, then the current is decreased until cooling down, and then current power is increased again.

This "self-cleansing" of the bulbs is the reason why many experimenters obtain poor results at the beginning of their experiments and only after longer use better successes.

With proper evacuation, the bulb shows an intensive fluorescing, and within the aforementioned dark spot opposite of the cathode, that means in our method—at the bottom; this part of the bulb is where the Roentgen rays emanate, and it is also the primary area where the cathode rays hit. When a strong magnet is brought close to the Hittorf tube, this spot moves and thus with the help of a magnet it is possible to arbitrarily shift the starting point of the Roentgen rays, which in certain circumstances can be of use for capturing different objects.

The intensity of the fluorescing spot varies in different stages of evacuation, but as we stated in our experiments, it is by no means to be regarded a full criterion for the power of the new rays emanating here; we had a number of long-used Hittorf tubes which only showed a yellow-green. Moderate fluorescing nevertheless yielded intense images in very short time, while other such tubes, which had a gorgeous emerald green fluorescence at the bottom, were only fairly effective photographically.

By contrast, the warming of the dark part of the bulb hit by the majority of the cathode rays appears to be a better criterion for the efficiency, in that this space works well for Hittorf tubes.

In one and the same evacuated glass container, different coloring of the fluorescent part of the bulb can be observed in stages of use, by the way the color is also influenced by the composition of the gas (see below). In our experiments, we have also been able to make the observation, that the surface of the glass becomes very strongly electrical and as a consequence of this circumstance, the Hittorf tubes are quickly covered by a layer of dust by attracting dust particles floating in the air.

We also want to mention, that next to other circumstances the effect of the vacuum tubes is also dependent on the thickness of the glass wall at the place where the cathode rays hit the latter, and the exposition time could probably be shortened considerably if [PAGE 7] in place of the glass one could use a more transparent material than mica, celluloid, thin aluminum plates, natural rubber etc. As this is difficult to accomplish, we have to at least strive and keep the glass wall of the bulb as thin as possible, in order to achieve as favorable results as possible in this way by shortening of the exposure time.

In our experiments, from all the various shapes of bulb-shaped containers, those which have as an anode a ring and as cathode an aluminum plate (see Fig. 2), which we described on p. 4, proved themselves best; when we work with the Rumkorff of 25 cm spark length usually employed by us, we obtained the best results when using a direct current of 1-2 amperes and about 180 volts (measured at the clamps) in the primary roll of the apparatus. We obtained excellent results with very short exposure time when using batteries or accumulators of 4 ampere and 6 to 20 volt with the above-mentioned vacuum tubes (fig. 4 and 5) of Prof. Kiss in Budapest, in which use of a medium sized Ruhmkorff sufficed.

Generally forms of the evacuated tubes with tightly confined bottom areas appeared more favorably than those with broad fluorescing areas, since in the first case the shadow images turn out more precise. However, by mounting perforated lead sheets one can stop down the rays, but even so moderately broad bulb-shaped or tube-shaped containers appeared more favorable to us.

The best positioning of the bulb against the object and the photographic plate during capture is that in which the direction of the cathode ray is perpendicular to the plate and the glowing green spot at the lower part of the bulb is directly turned towards the object to be photographed. The cathode rays leave the cathode, as said before, in the direction perpendicular to the respective area. But one can also detect a significant, if weaker, Roentgen ray effect at the side opposite to the anode in some circumstances; this is caused in that, as is well-known, during the discharge of the conventional Ruhmkorff inductorium no pure pole phenomena appear, but rather these are connected to the pole change, so that the cathode rays possibly dominate more or less at one electrode, but appear at the second electrode also.

Experiments were conducted to use conventional electric lamps in place of the Hittorf tubes. On this we mention, that the conventional electric lamps are made of a lead glass difficult to penetrate for the Roentgen rays, which shows a blue fluorescence phenomenon instead of the green one when the spark of an inductorium strikes through such lamps.

The experiment, which did not provide us with good results, can be performed in the manner that the thread is broken off by hitting the electrical bulb onto the open hand. Then both platinum wires are connected to the negative pole of the inductorium, and as positive electrode either a metal plate or an aluminum ring is used, which are situated outside of the bulb. A very high voltage is required; otherwise the ring or the metal plate has to lie against the bulb, which can very quickly result in striking through the glass.

To recognize whether the Hittorf tube emanates sufficient Roentgen rays, one can either employ a screen coated with barium platinocyanide, or create a little device made from a funnel shaped cardboard tube where on the bottom a piece of cardboard is mounted and has been coated with barium platinocyanide.[4]

[PAGE 8] In the first case, it is necessary to wrap the bulb and darken the room to be able to ascertain the fluorescence that occurs in the presence of the new rays, in the latter case it is sufficient to turn the funnel shaped tube against the light source and bring the eye towards the opening in the more narrow part of the funnel; in the presence of cathode rays a glowing of the bottom area can be ascertained. It only needs to be remarked that the cardboard must be coated with hot barium platinocyanide solution, so that tiny crystals copiously precipitate at the surface. It is even better when one sieves the barium platinocyanide in small crystals into the carton which has previously been coated with a shellac solution and serves either as screen or as bottom of the described device, in which manner very strong layers of barium platinocyanide are obtained which show the fluorescence phenomena excellently (cf. p. 6).

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[4] A similar device was recently described and recommended for “visibilization of Roentgen rays” by Prof. Salvioni under the name “Kryptoskop.”

Like the cassette, the light sensitive plate can be used locked in a wooden cassette or a conventional cardboard cassette, only in the first case care needs to be taken that the plate slide does not contain any metal component which would become noticeable in the capture on the plate. Usually we do not use a cassette but content ourselves to wrap the dry plate into two layers of black paper, as it is used for wrapping of the photographic plates. A single layer of such paper is not a sufficient protection against day- or lamp light, in that it can the easily happen that pinholes in the paper, undetectable to the eye, effect the development of black points with broadened edges on the plates during development.

During the experiments, humidity has to carefully be kept away from the photographic dry plate, since wet silver bromide gelatin layers have very little sensitivity to Roentgen rays and thus these plates do not blacken during development. Since the paper wrap does not offer sufficient protection against the penetration of humidity to the plate in cases where damp objects are to be photographed, we add a layer completely penetrable for Roentgen rays but inhibiting the humidity between the object and the dry plate, such as e.g. a piece of wood veneer, a mica plate 5, gutta-percha foil, or best a piece of celluloid, which however must be completely clear and free of added mineral substances. We carry out the fixing of the mica or celluloid film on the cardboard or paper wrap of the photographic plate by means of bee-glue 6 [beeswax]. One can also fix little objects in the image area itself onto the film by means of bee-wax since this is very well penetrable to the Roentgen rays.

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5 Such mica plates from very clean material are available in the sizes up to 18:24 from the Raphael Company in Breslau.

In our experiments with Roentgen rays we tested the behavior of different light sensitive layers towards these rays, namely: silver bromide gelatin plates of greater or lesser light sensitivity, further wet silver iodide collodion plates, silver bromide collodion plates, and wet eosin silver bromide collodion plates (Albert's emulsion) and lastly silver chlorobromide with alkaline development. It turned out that all kinds of collodion plates show either no or extraordinarily little sensitivity towards the action of the Roentgen rays. In contrast, both silver bromide gelatin as well as silver iodide gelatin and silver chlorobromide emulsion plates with alkaline development are sensitive to the action of these rays, namely at the most the pure silver bromide emulsion in the form of rapid dry plates (such as e.g. Schleussner's gelatin dry plates). The favorable influence of gelatin was noticeable especially in comparing a silver bromochloride gelatin plate to a wet collodion plate, which had the same sensitivity to white daylight; towards the Roentgen rays the wet collodion plate (silver iodide with acidic iron vitriol development) turned out to be [PAGE 9] nearly completely insensitive, while the silver bromochloride gelatin plate gave good results, even though commercially available portrait plates are more suitable.

We have not been able to make the observation that an orthochromatic eosin silver plate has greater sensitivity than a conventional silver bromide gelatin plate because our experiments yield the opposite. We could also determine that the sensitivity of the plates towards conventional light rays do not provide a measure for the higher or lower sensitivity of different plates towards Roentgen's rays. That is to say, we cut a silver bromide gelatin dry plate of 18° W and the same of 24° W in two parts, laid two different plate halves next to each other and exposed the same, wrapped well in paper, to Roentgen's rays. After the same exposure no substantial difference resulted. The experiment was repeated with samples with a scale photometer consisting of tin foil paper and the same result was achieved; even though the one plate is five times as sensitive to normal light rays than the other, nearly the same result was achieved towards Roentgen's rays!

Warming the plates during exposure to 40 – 60° C effects a substantial increase of sensitivity, as experiments we conducted owed. However, beware of warming too strongly or unevenly in that in this case spots would appear during development which are very distracting.

Regarding the distance of the light source and its position to the object to be pictured, the former is guided by the circumference and thickness of the object.

Flat little objects can be photographed with a close light source. Flat and extensive objects still allow for a small distance from the light source and in this way yield sharp images. However, objects that are rather thick and the impenetrable parts which are further distanced from the plate require that the light source should be mounted as high as possible above the object, which dramatically increases the exposure time. In this case, arrange the object towards the light source in such a manner that those details of which one wants very sharp pictures are at the axis of the bulb opposite of the middle point of the cathode. It is recommended to make the arrangement in such a way that the object to be pictured is hit from below or from the side by the rays (see Fig. 7 and 8 further below).

In most cases we use the light source above the object to be pictured, however illumination from the side or below is also sometimes used by us advantageously to picture objects which only could be pictured with difficulty in the opposite direction (more details on this on p. 12).

The initially mentioned experiments by Roentgen clearly show that it is not possible with Roentgen's rays to produce photographic pictures with the help of lenses and camera, as common in photography, rather the images obtained are silhouettes whose apparent three-dimensionality has its cause in the differing permeability of layers of different strength and different bodies. As the rays have no refractive power whatsoever and do not regularly get reflected, a body illuminated by them cannot be pictured by means of the pinhole camera in reflected light, but only by the light source directed; the experiment of Roentgen we repeated as follows: we brought a large lead sheet in a distance of 2/3 cm in front of the silver bromide plate wrapped in black paper, drilled a hole of about 2 mm diameter in the middle of this sheet and positioned the light source 10-20 cm in front. A pinhole camera image of the ray source occurred on the photographic plate which, in the case of sufficiently strong exposure, showed the form of the ray source.

[PAGE 10] The experiment with the pinhole camera is important because (as Prof. Roentgen has already shown) it proves that the rays essentially propagate linearly.

The images which can be obtained with the help of the new rays in the manner described are silhouettes; as said before a certain degree of apparent three-dimensionality is acquired through the differing penetrability of layers expressed in the image. We tried to obtain this three dimensionally, via suggestion from Prof. Dr. Mach in Vienna, and to conduct stereoscopic images by means of the Roentgen rays. For this purpose, the object, a mouse, was put on a glimmer plate clamped over two strips over the table plate and the plate wrapped in black paper was positioned there-under in such a manner that it came in contact with the mica plate, while the exchange of the plate for another was possible regardless without shifting the object. Now a ruler was mounted on the table parallel to the plate's edge, and marks were fixed to it in a distance of 10 cm to the left and right of the middle of the plate. The ray source was first positioned at about 30 cm high above the object in such a way that the middle of the bulb coincided with the one mark, then the axis was turned against the object, an exposure made, then the plate below the object was exchanged and the light source was moved in such a manner that the middle of the bulb would coincide with the second mark, again the axis was turned against the object and a second exposure made. The two images, seen in the stereoscope as slide positives, yielded a surprisingly three dimensional stereoscopic image of the mouse's skeleton. This kind of image should become appealing with some improvements of the apparatus for conducting the experiments, especially regarding objects of natural history.

As a guide for the penetrability of different organic and inorganic materials against Roentgen's rays we have reproduced one of our penetrability tests (see attached table) which shows a positive copy from the original negative, so that the darkest parts in the plate correspond to the highest shadow effect, or the least penetrability against Roentgen's rays, respectively.

The experiments showed that nearly all organic bodies are more or less easily penetrable for Roentgen's rays if they do not contain dense metals etc., but only consist of carbon, hydrogen, nitrogen and oxygen.

From the respective table it emerges that the magnesium band (1/10 mm and ½ mm) is very penetrable (No. 3) similar to tin foil (No. 5), which gives graduated transparency scales in layers of 0.1-1mm, reminiscent of the gradually staggered silk paper layers of scale photometers in use in photography. Nr. 1 and 2 show that copper and silver in 0.1 – 0.2 mm layers is not entirely impenetrable. In contrast, lead, platinum and gold put up a high resistance against penetration by Roentgen's rays, so that these metals can be considered practically impermeable, zinc as a thin sheet, nickel and iron, mercury in particular, are also strongly impermeable. The fact is interesting that quartz is not much more penetrable than crown glass and flint glass more strongly detains Roentgen's rays than crown glass (No. 7, 8, 11, 12, 14, 15).

A glass thickness of 1 mm weakens, even when using the purest crown glass or white solid glass of similar consistency; Roentgen's rays are stronger than an aluminum sheet of the same thickness (No. 9). In contrast, 1 cm thick aluminum metal already blocks the penetration of the rays considerably. A 1 mm thick layer of bone or mother of pearl absorbed the rays as strongly as glass on average. Regarding the different kinds of wood it has to be mentioned that generally wood of 1 cm thickness weakens the rays very little; especially this is true for soft wood, the permeability of which is a little larger than that of [PAGE 11] hard wood (No. 13 and 16), however the difference is not essential. Many types of wood reveal a clear structure, in particular palm wood, in which the silica containing parts can clearly be recognized due to their higher impermeability. Investigated by us were: spruce, pine, linden, pear, maple, mahogany and palmtree wood. It is remarkable that ebony has a noticeably lower penetrability for these rays, which is probably caused by its higher ash (calcium carbonate) content.

A meat layer of 1 cm thickness (No. 22) is approximately of similar penetrability like a 1 cm bone layer (No. 18); horn (No. 19) behaves rather similarly as meat. Caoutchouc [rubber] and wax (No. 20 and 21) are very penetrable, as are strong leather, woolen cloth, linen, medical dresses (No. 25-27), mica, especially though celluloid (No. 23).

Carbon in the form of black coal, charcoal, soot, graphite or diamond is very penetrable for the Roentgen rays. We have investigated these bodies in layers of the same thickness in addition to other materials, such as phosphor, selenium and sulfur, among the three of which phosphor has the largest and selenium the lowest penetrability.

A fair number of different gemstones with equal densities [were examined], such as diamond, ruby, emerald, topaz, sapphire, garnet, tourmaline, orthoclase, and mountain crystal; and further, amber, false and genuine pearls, and glass were examined in comparison. It was shown that the diamond has the largest penetrability of all of these materials. Close to it amber follows, which is very penetrable to the rays much like the different coals [carbons]. A comparison of the gemstones mentioned above regarding their penetrability towards Roentgen's rays shows that this is not strictly proportional to their density; diamond e.g. is much more penetrable compared to the other rocks, while the permeability of sapphire and ruby (which consist of aluminum oxide) is close to that of aluminum. Topaz, tourmaline and mountain crystal follow on these gemstones. Generally it was shown that for gemology no practical use of Roentgen's rays emerged (other than examining diamonds for genuineness) in this way at this point. True pearls are more penetrable than glass pearls, which is not caused by the insignificant content of organic substances of the true pearls, even though the calcium carbonate which participates in their composition is impermeable.

Attempts to determine the permeability of black coal showed well defined crystal groups in the images which correspond to the scattered crystals of pyrite in thee black coal pieces of 1 cm thickness, and strips corresponding to the carbonaceous shale lacing the coal.

The cameos pictured in the sixth plate (facsimile of the negative[6]) clearly demonstrate the impermeability of the material with increasing layer thickness. The cameos discussed are cut in onyx, a rock which practically solely consists of silica and in this regard behaves nearly like quartz (see No. 7 and 8, plate V). These cameos, which we borrowed with permission of his Excellency Sovereign Chamberlain Count Trautmannsdorff from the rich collections of the royal and imperial court museum, are encased in a medallion-like fashion in gold hoops and this frame is impermeable for the Roentgen rays in the image, in addition to the fine details of the high relief which are well expressed in the image. We will not reproduce the images easily made with the Roentgen procedure showing the content of wooden cassettes, money - [PAGE 12] bags etc. A popular lecture experiment involves laying a dry plate into a cardboard cassette or enclosing it in black paper (see p.*0, putting a key, rings, chains etc, on top, putting a panel from soft wood about 1-3 cm thick on top and mounting the Hittorf tube in a distance of 15-20 cm; in 10-3- minutes a clear, a well developed photographic image appears on the plate. The experiment can easily be varied into that one encloses the metal objects in wood or cardboard cassettes, such as small money bags with a metal bracket and money content, drawing instruments or weight cartridges in closed little wooden boxes on the plate etc. A good impression is always made by a wooden cassette screwed together with iron screws, with the side walls screwed into the bottom, so that the iron screw runs parallel over the plate along with it etc.

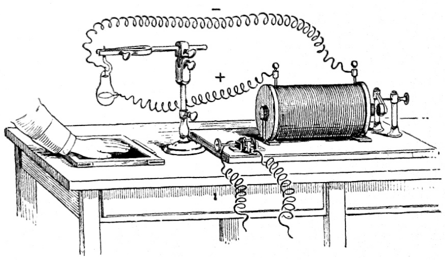

Fig. 7.

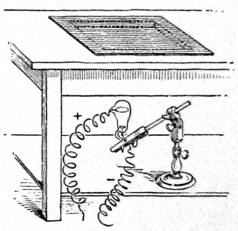

Fig. 8.

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[6] Of course in the negative (i.e in this plate as well as all those which show facsimiles of the original negatives) white parts correspond to the lowest permeability of the object against Roentgen's rays while in the positive prints the opposite is the case. In the plates included we apply both methods since either of them has their advantages in particular cases and influences the image effect.

Special interest is aroused by experiments to radiograph human limbs with the Roentgen rays, e.g. the photography of the skeleton of a hand or the foot. Our experimental setup for this is shown in Fig. 7. The electrodes of a Ruhmkorff inductorium are connected with the bulb-shaped Hittorf container in such a manner that the cathode is on top and the cathode rays perpendicularly fall on the table area. A moveable wooden stand into which the bulb is clamped facilitates the arrangement. By turning the off-switch at the feeding wires the correct current feeding can soon be noticed, which effects the appearance of the brightest green fluorescence at the bottom of the bulb; the distance is depending on the shortness of exposure time soon smaller, soon larger; for the photography of hands we choose 15-30 cm distance. In doing so the exposure time under unfavorable conditions takes about half an hour to an hour: when using especially effective bulbs, whose inner resistance is brought to the exciting spark, good skeleton images are obtained after 1 minute. The photographic plate (we usually work with Schleussner plates) is in a cardboard cassette at the table, or better: the plate is tightly wrapped in light-proof double black paper, the ends of which are folded towards the back of the glass wall of the plate and adhered there with some thick gum arabic. The plate is laid with the coated side on top, a same-sized mica or celluloid sheet, which is fixed at the corners by means of bee glue to the plate cover, serves for protection against sweat and humidity. Then the hand is pressed to it directly, the electric spark is conducted through the bulb and the experiment has thus begun. For children or nervous people who cannot stay calm during the required length of exposure, the hands are fixed to the photographic plate (or cassette, respectively) by means of dressing, or also their fingertips are fixed with some bee glue, optionally supported with cotton sticks, the materials of which only imperceptibly hinder the Roentgen rays.

Sometimes it is desirable to radiograph limbs from below. Of course in this case the photographic plate is laid on top. The photography of the carpal bones [PAGE 13] will be focused when using this setup. The photography of the female hand as well as that of the arm of a four year old child (see the plates) have been made that way. Fig. 8 shows this experiment. In a table plate, an opening is cut and covered with a moderately thick cardboard, since this offers less hindrance to the permeation by Roentgen's rays than the table plate. Below is the evacuated bulb arranged accordingly. On top of the cardboard the hand is laid on the back of which the photographic plate is immovably fixed with dressing.

Regarding bringing about the photographs obtained by means of Roentgen's rays on silver bromide gelatin plates, no special remarks are to be made. Any of the ordinary photographic developers is sufficient. Pyrogallol-soda as well as iron oxalate developer make the darkening appear easily to the backside of the photographic plate, which is more favorable for the power of the images than superficially operating rapid developers. The effect of strong Roentgen rays penetrates the entire thickness of the silver bromide gelatin layer, even a part of it penetrates the plate entirely and can have a noticeable effect on a second silver bromide plate laid behind. [7] Well and amply exposed plates thus clearly show the heaviest parts of the image from the back side of the plate. As fixer, acidic fixing bath is employed (sodium thiosulfate with added sodium hydrogen sulfite).

When only briefly exposing in these experiments, a clear outline of the outer hand is obtained but with low clarity of the [inner] skeleton. Upon ample exposure though the sinews-, fat- and muscle-areas as well as the skin and wrist cartilage are radiated through and a strong, well-defined shadow forms while a weakly toned shadow marks the soft parts. Depending on the duration of the exposure, the flesh can be “photographed away” to the most part or entirely, as can be seen from the first three plates, one of which (hand of a four year old child) corresponds to a long exposure, while the photography of the woman's hand was obtained by means of a medium exposure, and that of a girl's hand by short exposure. In these experiments it is noted that the bones themselves arguably are not very penetrable, but not completely impenetrable for Roentgen's rays, rather, indications of their inner structure are recognizable in the image; for instance one can find in the finger limbs that the side walls are differently rendered than the marrow volume, which in a way gives the viewer the impression of a three dimensional rendering; the loose bone matter at the end of the finger is distinguished and some details which relate to the growth and development of the bone can be discerned, and often a certain striation of the bone is also noticeable.

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[7] With common silver bromide plates the glass support has a strongly absorbing effect on the Roentgen rays. Silver bromide paper or films on celluloid or mica hinder the penetration of the rays to a much smaller extent, so that numerous such papers or films stacked on top of one another are penetrated and yield developable images identical to one another.

It is remarkable that the individual bones in the photographs of hands and feet (see the tables) made by Roentgen's procedure do not touch, as the cartilage and sinews that connect them, much like the flesh parts allow the rays free passage. With children and individuals in growth, whose bone ends are not entirely ossified yet, clearly separated little discs can be noted at the finger bones in the photographs, as is especially noticeable in the photography of the hand of a four year old child (see plate); it should be added that the skeleton of this child at the carpus is not normal, as the latter was suffering from rachitis [rickets], albeit in healing, and thus explains the low development of ossified little bones at the carpus, or, respectively, their incomplete presence because there are fewer of them than with normal hands).

We point out the highly interesting appearance of human hands in different stages of age in our photographs. Plate 1 shows the hand of a woman of 21 years; [PAGE 14] the ossification of her finger bones has already taken place. A clear definition is noticeable from the finger tips to the arm bones. In this image, the little bone is of interest and is found by the bending sinew of the thumb, it is called the sesamoid bone; such little bones develop at sinews here and there, but this does not occur regularly and is not a pathological condition either.

In the following tables we see the hands of a four year old boy and an eight year old girl – in these images the growth phases of the finger bones in development are clearly discernible. In both hands the epiphysis of the middle hand bones and the phalanges, which are not osseously unified with the middle pieces, clearly appear. The next table shows the foot of a seventeen year old student, in which the little toe (due to wearing too tight shoes) is bent a little causing the abnormal shape of the bone along with the position of the flesh- and the skin enclosure can clearly be noted. We also photographed numerous distinctly pathological cases such as fractures of the hand and feet, the hand with gout swellings, foreign bodies (gun bullet) in hands, etc, without resulting in other aspects of the characteristic fashion of the method as we have described it here.

Professors Exner and Mosetig in Vienna succeeded on January 21 with the help of Roentgen's rays and gave provisional diagnoses; the photography showed the defect of a bone injured by a pistol shot of a man to be operated; with another patient the deformation of the left foot (double end phalanx bone at the big toe) was clearly seen; the photographs gave a handle for the exact determination of the operating area.

Medicine and surgery took advantage from the new development so far by photographing complicated bone fractures, foreign objects in the limbs, double bones etc. from different sides with the help of Roentgen's rays. The initial expectations were very enthusiastic; however, a certain disappointment did not fail to appear and in some circles the opposite mistake was made to entirely deny the value of the new discovery, which was not justified, as the successes made in Vienna and other places showed. Today it is not possible, as a consequence of the strength of the ray source, which is insufficient for certain applications, to photograph through the torso of a grown-up to find gall stones. Prompted by Dr Siegl, we photographed a series of gall stones and were able to determine that some calciferous gall stones are difficult, others were easy for Roentgen rays to penetrate; to determine the same in the gall of the living individual has not been possible yet following the method outlined above; thus the applicability of the method for now is limited to limbs, etc. Thus in the photochemical laboratory of the Royal and Imperial Teaching and Experimentation Institute for Photography and Reproduction Techniques we photographed the hand of Councilor of Commerce H. who carried a gun bullet stuck in the middle hand bones since the German-French war, and showed the deformation of bullet and bone. On February 10th, upon request of the board of the Merciful Brothers in Vienna, the fracture of a foot of a patient was photographed. The result was good in that the entire complicated fracture and the kind of growing together of the fractured bone parts were clearly discernible in the image.

An interesting case was the photography taken on February 10th of the current year of the hand of a worker, which was covered by gout lumps. The image only shows insignificant changes of the bones themselves, the hard thickenings are likely purely cartilage.

The applicability of the method for certain methods of antiquity studies was proven by the following case: prompted by Dr. Dedekind, custos [archivist or director] of the Egyptian Department of [PAGE 15] the Imperial-Royal Museum of Art History [also known as the Museum of Fine Arts] in Vienna, on February 11th an experiment of photographing the content of a rare unopened mummy with the help of Roentgen's rays was conducted. This mummy, which has the outer form of a human shape, was believed to be an IBIS mummy and considered sacred by the old Egyptians, however this assumption was unproven. As it was undesirable to unwrap the mummy which was considered unique, the only method to ascertain its content appeared to be the photography by means of Roentgen's rays. With permission of his Excellency Royal Household Officer Count Trautmannsdorf, the mummy was brought into the photochemical experimental laboratory of the aforementioned institution and the part of the mummy, which in its form corresponded to the head and shoulders of a human person, was exposed with Roentgen's rays, and the photography clearly yielded the outline of bird's bones and the absence of human skeletal parts. Thus the content of the mummy, now definitely to be called an IBIS mummy, is ascertained and the use of the new method for similar purposes of Egyptology has been demonstrated.

The use of the procedure for the purpose of zoology should not be without interest. The applicability in this direction shall be demonstrated by the illustrations on the plates included. In doing so we mention that Assistant Heinrich Kessler supported us with all these illustrations in a most thankworthy manner.

The seventh plate shows the image of a green lizard, which we photographed shortly after its demise in top view. In its interior, the ribs and the spinous process are seen, which gradually shorten towards the back tail vertebrae and the more transparent lung is hinted in our plate. The image is a positive.

The next plate is also a positive; it includes the depiction of a chameleon (Chamaleon cristatus), a species limited to Africa but frequently occurring there. The animal, which was stored in spirits for a long time, has been kindly made available to us much like many other specimens from the collections of the Imperial Natural History Museum. In such cases during exposure one needs to consider that upon longer duration of exposure there is a risk of double contours due to evaporation of the spirits and the resulting shrinkage of the specimen.

The following three plates contain depictions of fishes. One of these is a positive print, i.e. the depiction of the two sea fishes, of which one (Acanthurus nigros- [Bluelined surgeonfish) was caught near the Society Islands, the other (Zanclus cornutus) close to the Sandwich Islands, are notable for their strange shape; the first carries an erectable sting concealed in a furrow to each side of the tail and has nine dorsal spines and thirteen tail vertebrae while the latter is elongated one vertebra each and a dorsal fin occupied with seven stings, the third of which is very much elongated.

With Roentgen's rays imaging the different fishes, the skins of the fin rays of the back and belly appear clearly and the inner skeleton is discernible. The appearance of the air bladder is remarkable, which for instance is simple with the branzino (seabass, Labrax lupus), with the goldfish clearly constricted, while the sole fish (Pleuronectes solea, Linnaeus) is among the fishes that do not have an air bladder, as is discernible on the heliographic plate. These latter fishes were fresh as opposed to the preserved specimens in spirits whose air bladders are blurry. Other than that such specimens give quite good skeleton images, as demonstrated by the Christiceps argentatus (a combtooth blenny not rare in the Adriatic Ocean) depicted in our plate, which has two dorsal fins, while the fishes in plate IX are made after such specimens. Other than that we have to remark that we found that the scales of the various fishes vary in [PAGE 16] transparency with the use of Roentgen's rays, which can be explained by their differing lime content or the varying thickness of the scales. Goldfish e.g. can easily be photographed even with fairly bright light sources in a few minutes, while the bass is much harder to penetrate.

The appearance of the photography of frogs made with Roentgen's rays is interesting (see plate). These were killed with strychnine and one was laid on the photographic plate on its belly, the other one in the back position. In the first case skull bones and jaw, in the latter case the spine and the pelvic bones appear more clearly; always the surrounding flesh is visible and one notices the hollow thin bone, the inner of which is filed with less dense marrow.

The photography of a rat (thirteenth plate) required a two to three times longer exposure time as we needed for lizards, snakes, little fishes etc. The light easily goes through the fur of the animal and marks the skeleton, particularly the dentition, spine and tail as well as the finely formed feet bones.

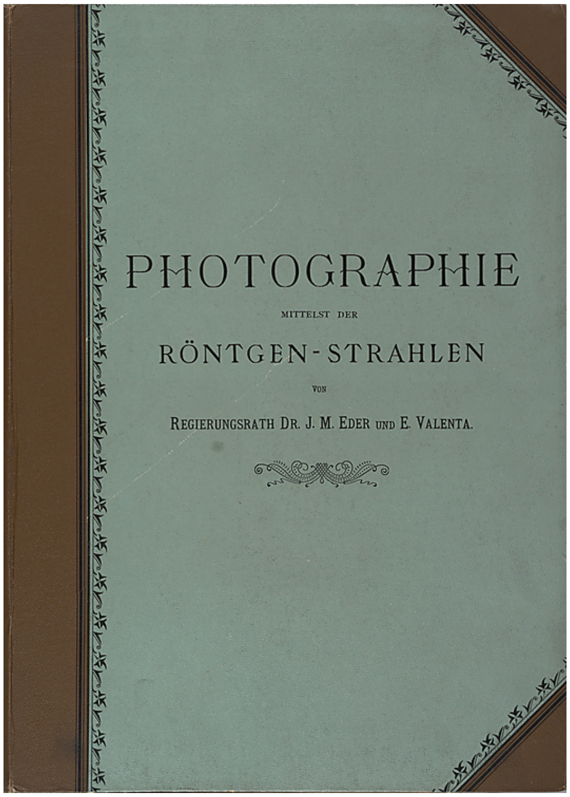
The newly born rabbit (see the respective plate) shows the bone development of what we mentioned earlier regarding the child's hand, i.e. the seemingly loose embedding of the individual little bones in the body to an even higher extent; individual cartilage regions are indicated, while other parts connecting the bones cannot be seen at all. The comparison of the image of the adult rat with that of the young rabbit is an instructive one since it allows us to see the growth process of these animals.

The snake on the last plate was killed immediately before the experiment by means of chloroform; this is an Asclepius snake. Clearly the head skeleton can be seen, the spine along with the ribs, as well as the outer contours of the delicately wound snake body. Close to the anus, long nontransparent pieces of the cloaca's content can be discerned.

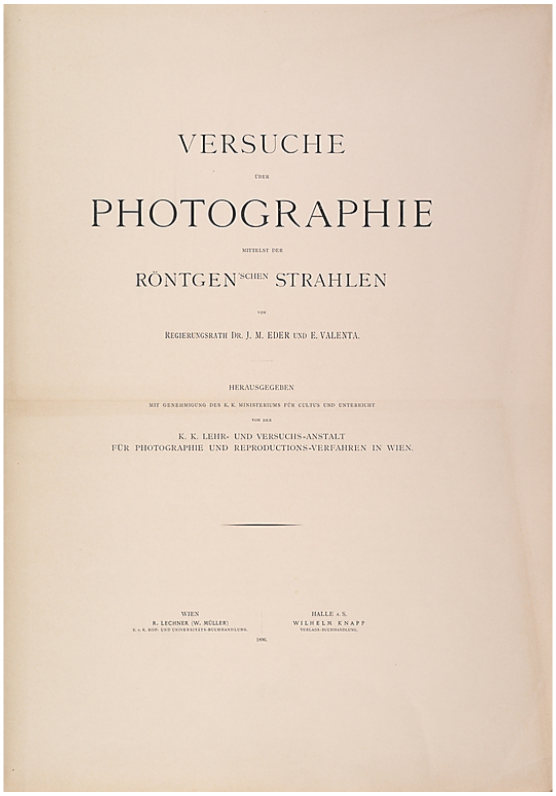
The illustration plates described – in their entirely accurate reproductions of the original negatives – have been made by means of heliogravure, i.e. partly in the Imperial-Royal Institute for Military Geography, partly at the Blechinger Company in Vienna, who used great care in doing so. All negatives, or diapositives, respectively, as well as zincography for the illustrations within the text were made at the Imperial-Royal Institute for Teaching and Experimenting in Photography and Reproduction technologies in Vienna. We believe we have made the potential use of Roentgen's method apparent by publishing the experimental results outlined above obtained at the Imperial-Royal Institute for Teaching and Experimenting in Photography and Reproduction in Vienna and hope that the method can still be improved substantially and will prove fruitful in numerous disciplines of science.

Vienna, February 1896

THE ATLAS



PHOTOGRAPHIE
MITTELST DER
RÖNTGEN-STRAHLEN
VON
REGIERUNGSRATH DR. J. M. EDER UND E. VALENTA.



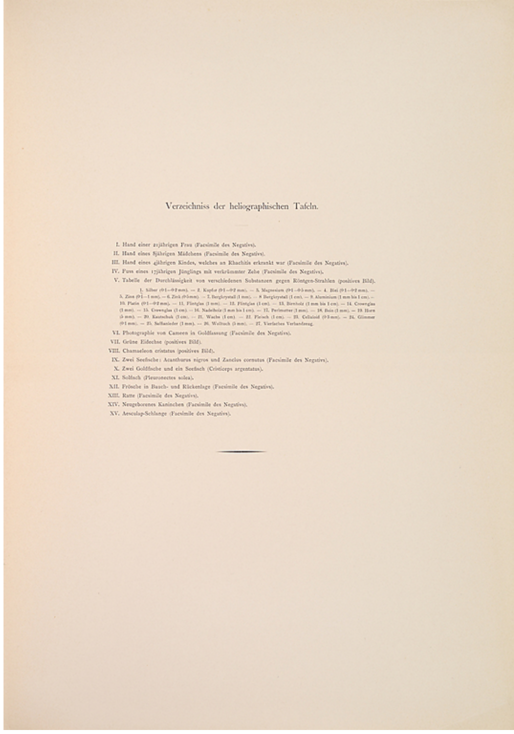
VERSUCHE
ÜBER
PHOTOGRAPHIE
MITTELST DER
RÖNTGEN'SCHEN STRAHLEN
VON
REGIERUNGSRATH DR. J. M. EDER UND E. VALENTA.

HERAUSGEGEBEN
MIT GENEHMIGUNG DES K. K. MINISTERIUMS FÜR CULTUS UND UNTERRICHT
VON DER
K. K. LEHR- UND VERSUCHS-ANSTALT
FÜR PHOTOGRAPHIE UND REPRODUCTIONS-VERFAHREN IN WIEN.

WIEN
R. LECHNER (W. MÜLLER)
K. u. K. HOF- UND UNIVERSITÄTS-BUCHHANDLUNG.

HALLE a. S.
WILHELM KNAPP
VERLAGS-BUCHHANDLUNG.

1896.



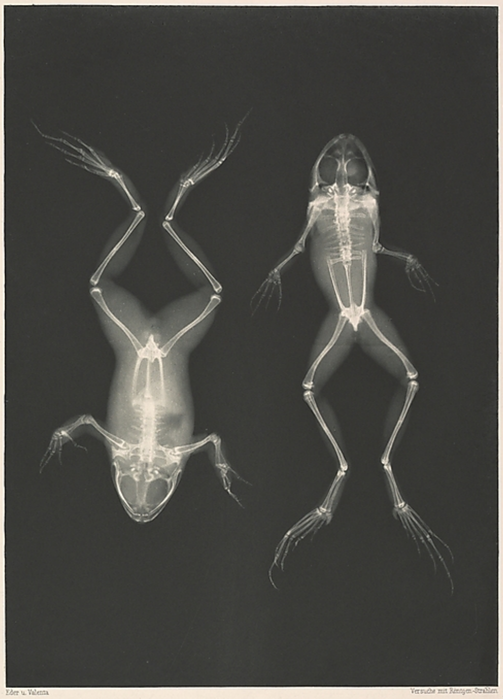
Verzeichniss der heliographischen Tafeln.

I. Hand einer 21jährigen Frau (Facsimile des Negativs).
II. Hand eines 8jährigen Mädchens (Facsimile des Negativs).
III. Hand eines 4jährigen Kindes, welches an Rhachitis erkrankt war (Facsimile des Negativs).
IV. Fuss eines 17jährigen Jünglings mit verkrümmter Zehe (Facsimile des Negativs).
V. Tabelle der Durchlässigkeit von verschiedenen Substanzen gegen Röntgen-Strahlen (positives Bild).

1. Silber (0·1—0·2 mm). — 2. Kupfer (0·1—0·2 mm). — 3. Magnesium (0·1—0·5 mm). — 4. Blei (0·1—0·2 mm). — 5. Zinn (0·1—1 mm). — 6. Zink (0·5 mm). — 7. Bergkrystall (1 mm). — 8 Bergkrystall (1 cm). — 9. Aluminium (1 mm bis 1 cm). — 10. Platin (0·1—0·2 mm). — 11. Flintglas (1 mm). — 12. Flintglas (1 cm). — 13. Birnholz (1 mm bis 1 cm). — 14. Crownglas (1 mm). — 15. Crownglas (1 cm). — 16. Nadelholz (1 mm bis 1 cm). — 17. Perlmutter (1 mm). — 18. Bein (1 mm). — 19. Horn (5 mm). — 20. Kautschuk (1 cm). — 21. Wachs (1 cm). — 22. Fleisch (1 cm). — 23. Celluloid (0·3 mm). — 24. Glimmer (0·1 mm). — 25. Saffianleder (1 mm). — 26. Wolltuch (5 mm). — 27. Vierfaches Verbandzeug.

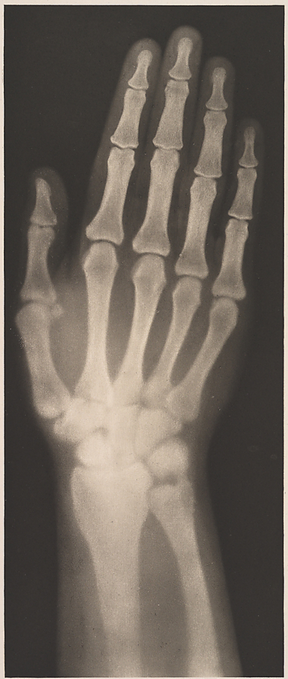
VI. Photographie von Cameen in Goldfassung (Facsimile des Negativs).
VII. Grüne Eidechse (positives Bild).
VIII. Chamaeleon cristatus (positives Bild).
IX. Zwei Seefische: Acanthurus nigros und Zanclus cornutus (Facsimile des Negativs).
X. Zwei Goldfische und ein Seefisch (Cristiceps argentatus).
XI. Solfisch (Pleuronectes solea).
XII. Frösche in Bauch- und Rückenlage (Facsimile des Negativs).
XIII. Ratte (Facsimile des Negativs).
XIV. Neugeborenes Kaninchen (Facsimile des Negativs).
XV. Aesculap-Schlange (Facsimile des Negativs).

PHOTOGRAVURE PLATES



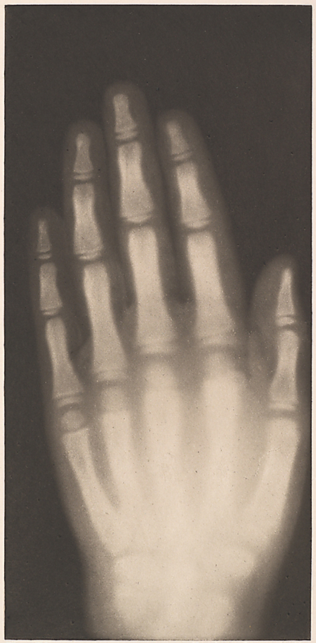
Eder u. Valenta. Versuche mit Röntgen-Strahlen.

Frösche in Bauch-und Rückenlage.



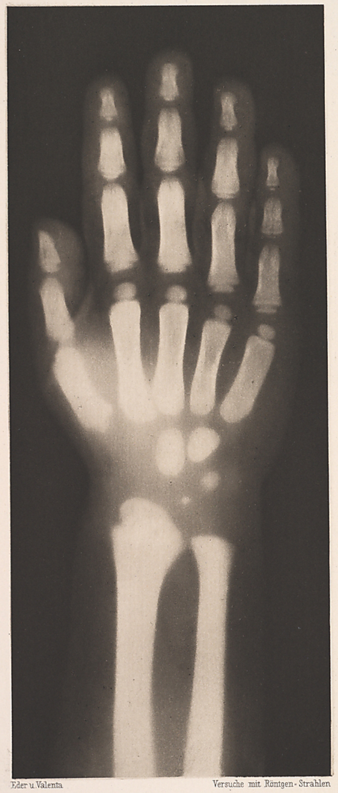
Eder u. Valenta. Versuche mit Röntgen-Strahlen.

Frauenhand.



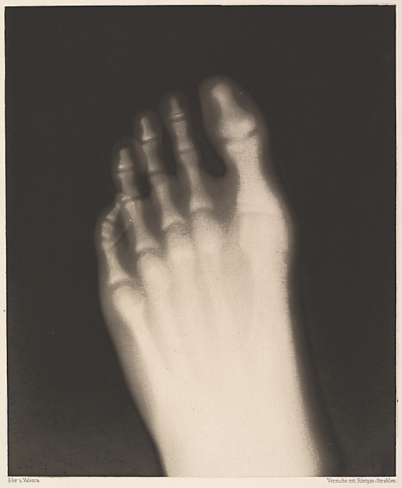
Eder u. Valenta. Versuche mit Röntgen-Strahlen

Hand eines 8 jährigen Mädchens.



Eder u. Valenta. Versuche mit Röntgen-Strahlen

Hand eines 4 jährigen Kindes.



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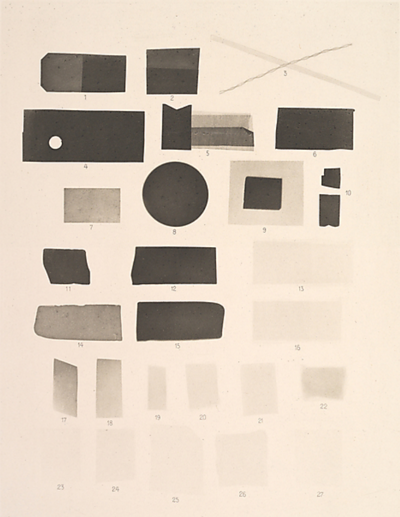
Fuſs eines 17 jährigen Jünglings.



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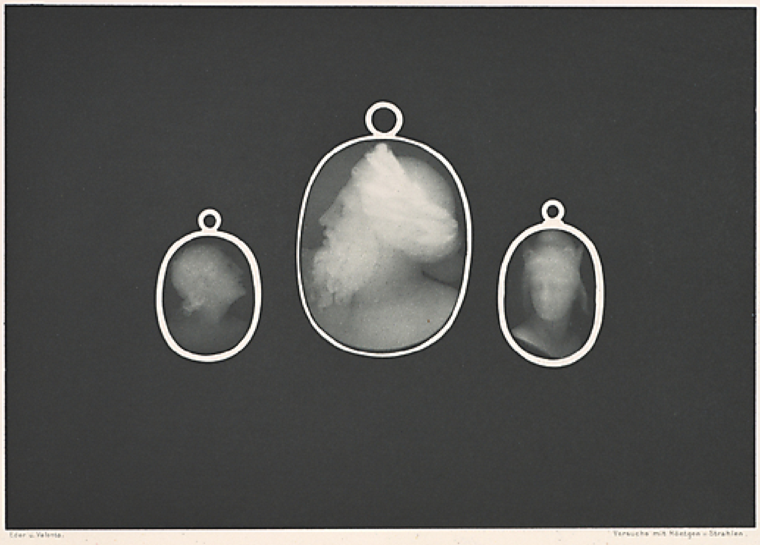

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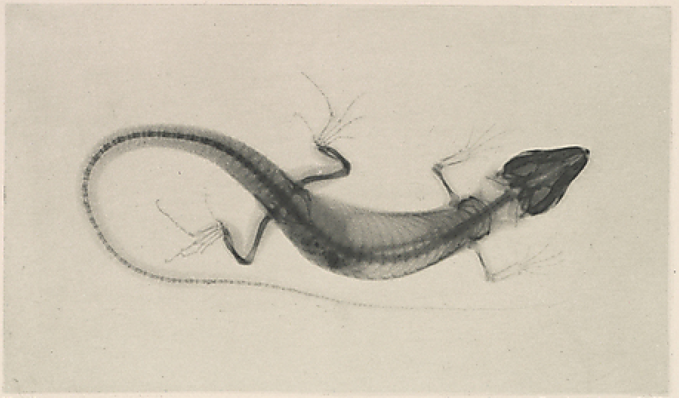
CAMEEN IN GOLDFASSUNG.



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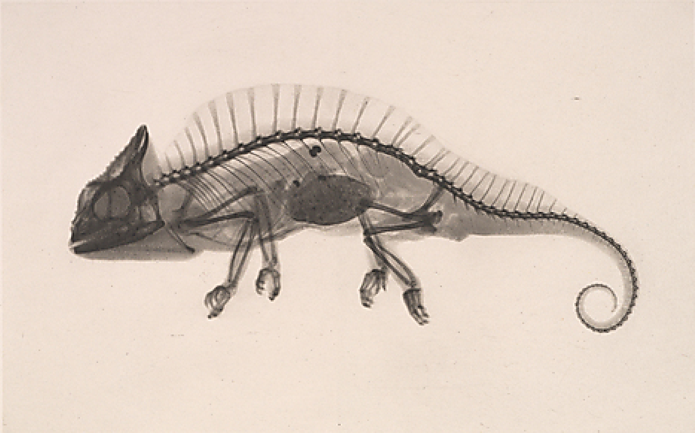
Grüne Eidechse.



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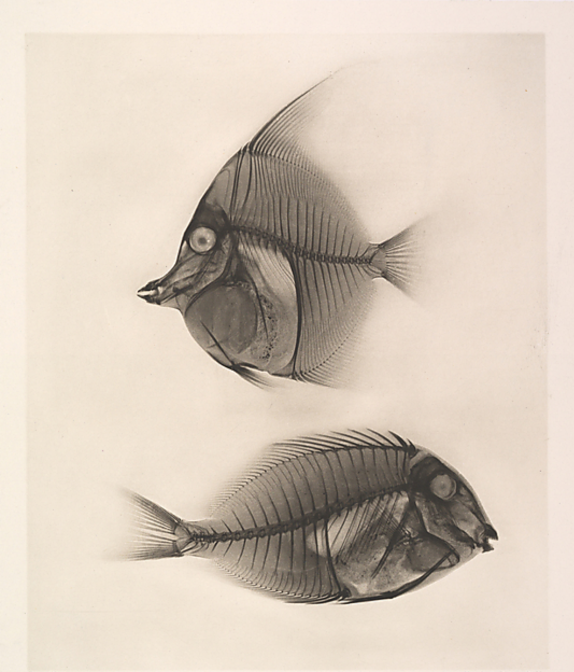
Chamäleon cristatus.



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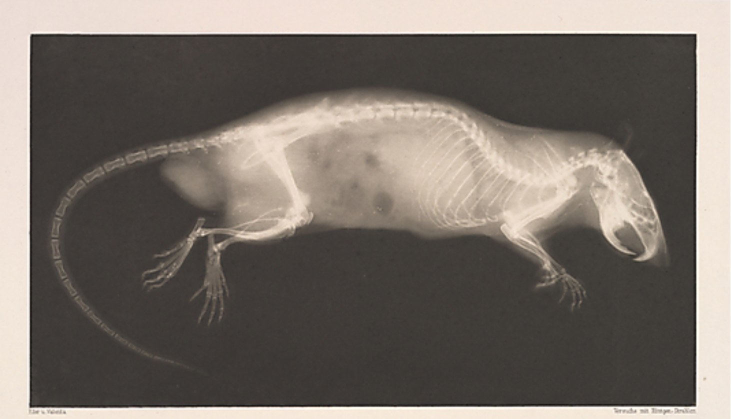
Zanclus cornutus. | Acanthurus nigros.



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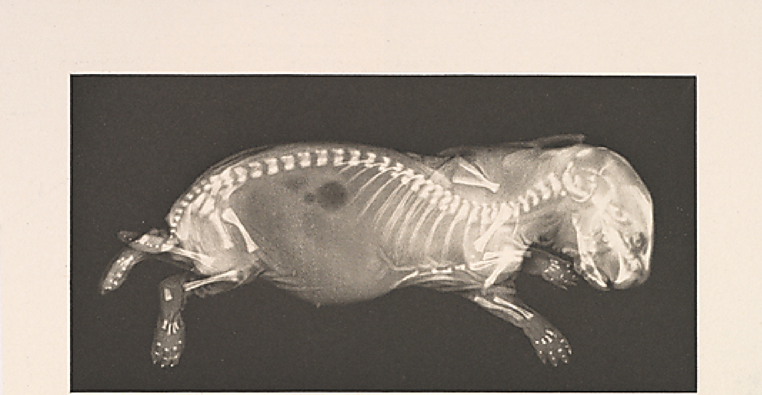
Ratte.



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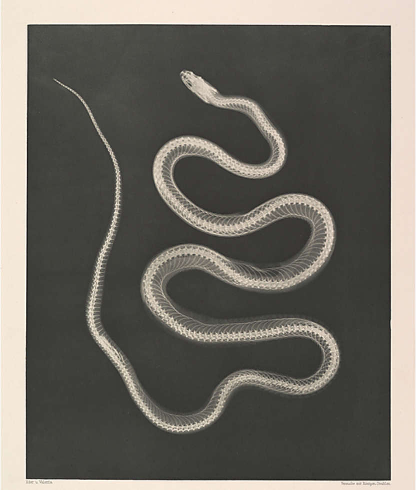
Neugeborenes Kaninchen.



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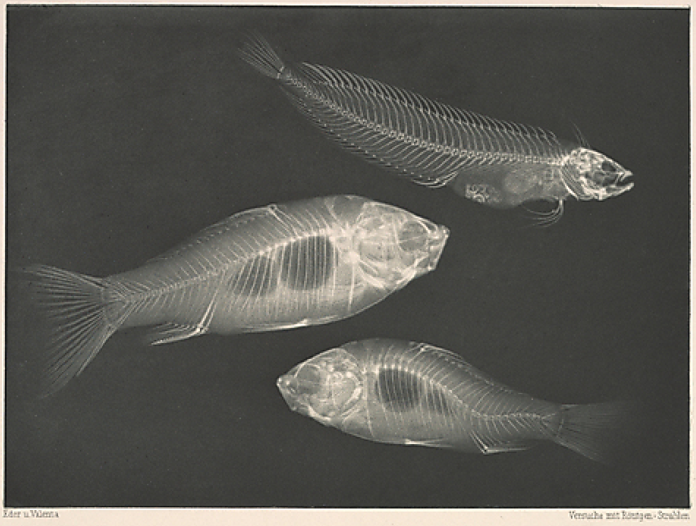
Aesculap-Schlange.



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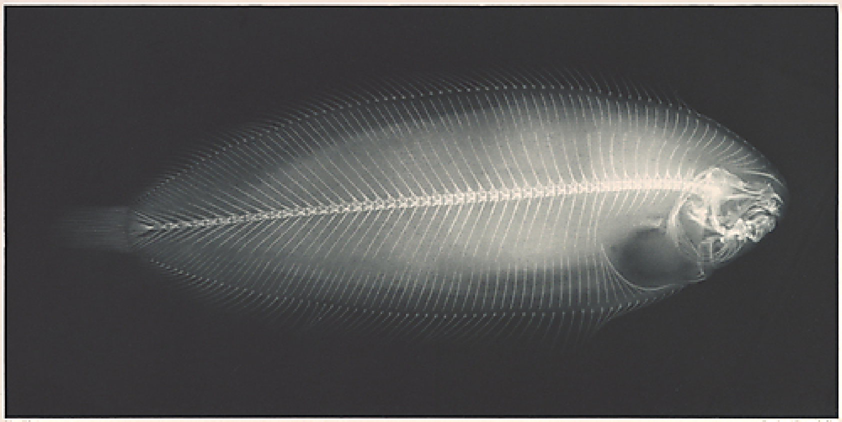
Versuche mit Röntgen-Strahlen

Zwei Goldfische und ein Seefisch (Christiceps argentatus).



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Versuche mit Röntgen-Strahlen

Solfisch (Pleuronectes solea)